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PRELIMINARY OBSERVATIONS ON THE MORTALITY OF PINE SEEDLINGS IN FROST POCKETS

Project P-372

by

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"A factor of great significance in the survival of plants which grow in regions subject to freezing temperatures at some season of the year is that relating to their resistance to freezing" (1). Although trees normally protect themselves against winter frosts by a gradual hardening process, and by decreased respiration, they are susceptible, in varying degrees, to unseasonable frosts. That foresters would be well advised to bear this in mind, particularly with regard to obtaining and maintaining reproduction, is illustrated by an investigation conducted at the Petawawa Forest Experiment Station near Pembroke, Ontario, in September, 1952.

An outwash kettle or pot-hole was chosen as the site of the investigation with stations at five different elevations (Figure 1). Such depressions are usually frost pockets in which damaging frosts can occur even though temperatures in the surrounding area are above freezing (2).

These frosts are caused by a combination of long-wave radiation from the surface, and cold air drainage. At night the earth loses heat by long-wave radiation into space, thus cooling the surface of the earth and the layers of air next to it. This cooling may be offset by the long waves being reflected back by clouds, and by the action of wind in mixing the cool air near the surface with the warmer air above. On ordinary topography where the cool air--being heavier--flows down the slope and is replaced by warmer air, no low temperatures develop. But wherever the cool air accumulates, very low temperatures result. This occurs on flats and wherever air-drainage is impeded; and is especially pronounced in pot-holes.

Nursery-grown red pine and jack pine were placed at each station and screened against rodents. Some of these seedlings were two months old and woody; some were only a month old and still succulent. Because these seedlings were grown in special containers, later sunk to ground level at the experiment site, subsequent mortality from transplanting shock was probably eliminated. Shielded thermometers were placed at each station and minimum temperatures (in degrees Fahrenheit) twelve inches above the surface, were recorded daily from September 7 to September 29.

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A representative profile of the kettle (Figure 2) shows minimum temperatures at each station on three typical nights. Minimum temperatures at headquarters, approximately three miles northeast of the area where a standard meteorological station is maintained, are also shown.

During the early morning hours of September 7 and 8, although the temperature at headquarters did not fall below freezing, eighteen and eight degrees of frost were recorded at stations 1 and 3 respectively. By mid-morning on September 8, with two exceptions, all seedlings at stations 1, 2, and 5 had turned a deep reddish-brown. That this pronounced discolouration indicated mortality was borne out by the failure of these seedlings to recover. The two survivors, one at station 1, the other at station 2, were both in the centre of clumps of seedlings. Mortality at station 4 (same elevation as stations 2 and 5) was light among the succulent seedlings and the older seedlings were practically undamaged. Station 4, with a northerly aspect, was sheltered by a few trees immediately above it; while station 5 with an eastern aspect was fully exposed. Since the seedlings at both stations were subjected to the same intensity of frost, it is suggested the greater mortality of station 5 resulted from a more rapid freezing and thawing than occurred at the more sheltered station. Mortality of seedlings situated more than seven feet above the bottom of the pocket decreased with increasing elevation. None of the seedlings at station 3, for example, on the rim of the depression, showed any evidence of injury--despite eight degrees of frost. All seedlings that survived this initial severe frost later withstood as much as seventeen degrees of frost without any apparent ill effects.

In order to confirm the observed killing effect of frost, two additional sets of red pine and jack pine seedlings were placed at station 5 on September 20. One set was left exposed; the second was covered with a double screen of cello-glass insulated with aluminum foil, excelsior, and corrugated paper. The exposed seedlings withstood nine degrees of frost without damage, but on the night of September 26, the temperature dropped to 15°F. (17 degrees of frost) killing all the exposed seedlings. No damage to the sheltered seedlings could be detected, despite thirteen degrees of frost inside the shelter.

This experiment demonstrated the killing effect of frost on young unhardened red pine and jack pine. The results suggest a relation between frost resistance and age. While they suggest a critical minimum temperature below which exposed seedlings are killed, the results further indicate that certain environmental features such as aspect and exposure may increase or lessen the danger of mortality from freezing, depending upon whether they speed up or retard the freezing and thawing processes.

The effect of the very remarkable variation in temperature within this shallow kettle on young seedlings suggests that an understanding of temperature patterns within such depressions, and a knowledge of the frost resistance of different species, is essential if such areas are to be successfully reforested either by seeding or planting--with a minimum expenditure of time and money.

Because of the influence of topography on cold air drainage, unseasonable frosts occur more frequently and with greater severity in depressions. However, any low-lying areas, such as pine flats, are potential frost areas in any unseasonable cold period; on flats cut-over, especially localized clear-cuts, the likelihood of frost is increased since, in effect, pockets are created into which cold air drains. The killing effect of frost may therefore have more bearing on regeneration failures than has previously been considered likely.

References

(1) Curtis, O.F. and D.G. Clark. Introduction to plant physiology. McGraw-Hill Book Co., New York, 1949.

(2) Geiger, R. The climate near the ground. Harvard University Press, Cambridge, 1950.

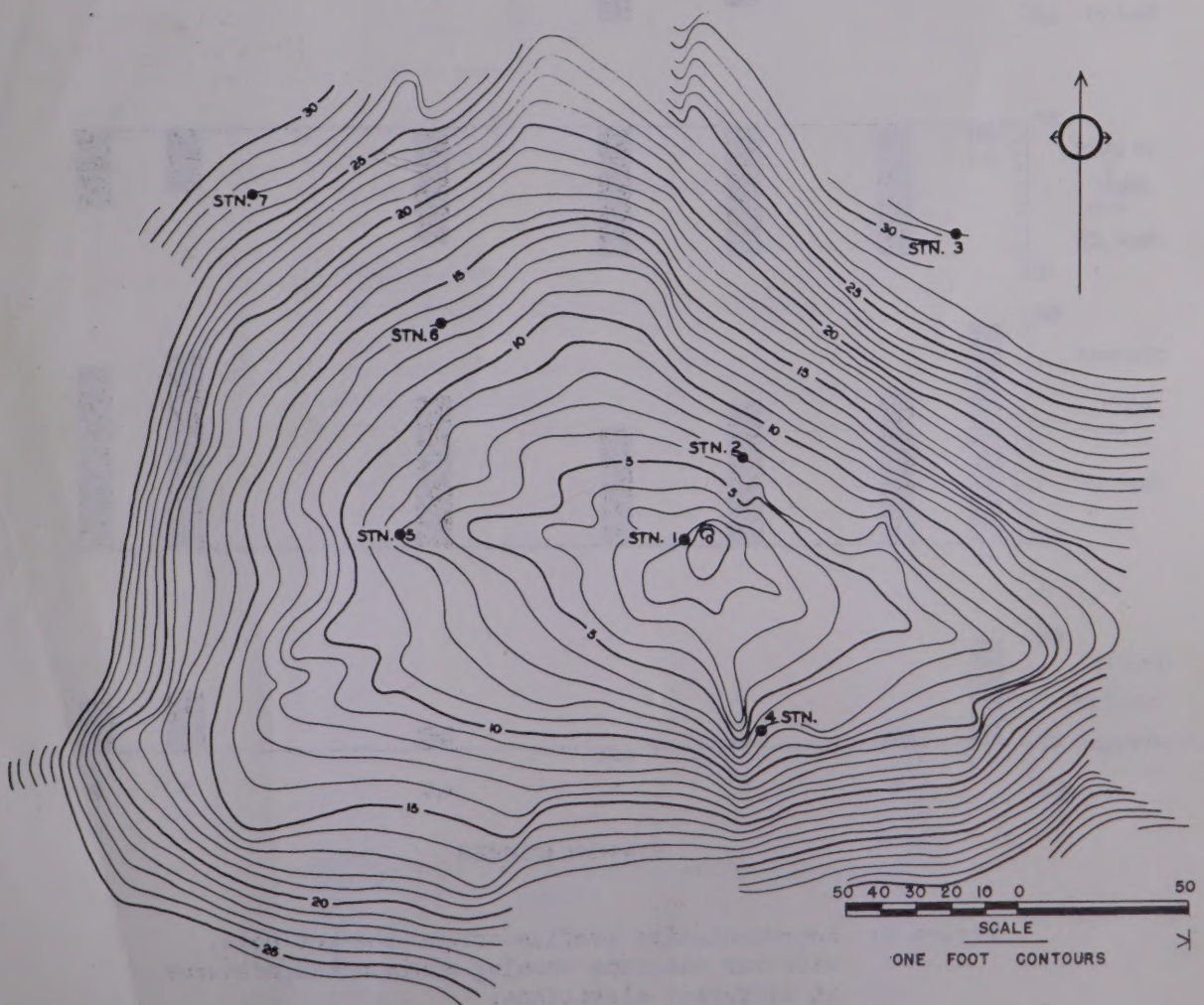

Figure 1: Contour map of outwash pot-hole showing location of stations.

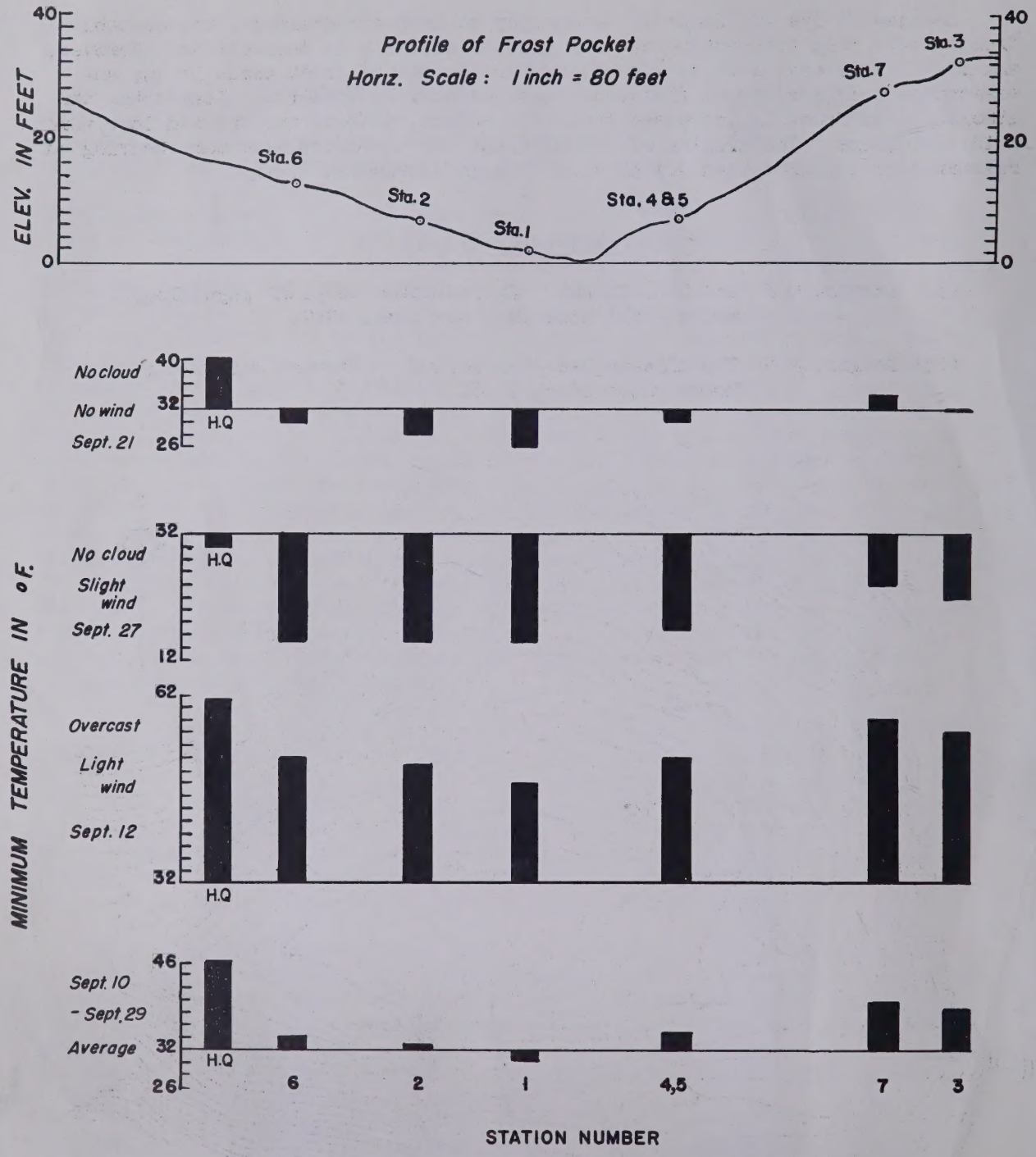

Figure 2: Representative profile across the pot-hole, with bar diagrams showing minimum temperatures at different elevations.